PENNONI ASSOCIATES INC.
CONSULTING ENGINEERS

March 27, 2015

Design Level Inspection Report
I-95 Wilmington Viaduct

Re: Concrete Coring and Testing Services
Bridge I-748 North and South Bound
I-95 Viaduct, Wilmington, DE

Pennoni Associates (Pennoni) visited the above referenced structure on the nights of November 19, 2014 and December 10, 11, 15, 17, 18 and 21, 2014 to drill and extract concrete core samples and perform overlay pull testing. A total of twenty two (22) concrete cores were extracted and transported to our laboratory where they were documented and tested for thickness, compressive strength and water soluble chloride ions. Eight (8) cores, 4 from each direction of the structure, were sent to Highbridge Materials, Inc. for petrography and air voids testing. Table 1 below summarizes the physical dimensions, locations and selected testing for each of the concrete cores extracted from Bridge I-748.

Table 1 - Core Locations, Dimensions and Prescribed Testing

Bridge	Core ID	Core Location				Core Diameter (in)	Core Thickness		Laboratory Testing
		Span	Lane	Distance from Joint (X) (ft)	Distance from Lane Line (Y) (Ft)		Overlay (in)	Structural (in)	
I-748 (NB)	748NB-1C	4	R	10.0	5.0	3.25	2.50	5.25	Compression
	748NB-2C	5	L	88.0	10.0	3.25	1.50	4.50	Compression
	748NB-3C	8	C	66.0	11.0	3.25	3.00	5.00	Compression
	748NB-4C	12	R	28.0	7.0	3.25	2.00	5.50	Compression Water Soluble Chloride
	748NB-5C	19	L	11.0	4.5	3.25	1.25	6.25	Compression Water Soluble Chloride
	748NB-6C	22	R	50.0	9.0	3.25	3.00	4.50	Compression
	748NB-7C	24	C	17.0	7.0	3.25	3.13	4.88	Compression
	748NB-1P	5	L	84.0	6.0	3.25	1.25	5.50	Petrography & Air Voids
	748NB-2P	8	C	82.0	1.0	3.25	3.00	5.00	Petrography & Air Voids
	748NB-3P	11	R	89.0	5.0	3.25	2.00	6.00	Petrography & Air Voids
	748NB-4P	24	C	52.0	8.0	3.25	3.00	4.50	Petrography & Air Voids
I-748 (SB)	748SB-1C	25	R	30.0	10.0	3.25	2.50	5.00	Compression
	748SB-2C	22	L	116.0	3.0	3.25	1.00	6.50	Compression Water Soluble Chloride
	748SB-3C	16	C	59.0	3.0	3.25	3.00	4.75	Compression
	748SB-4C	11	R	21.0	8.0	3.25	2.50	4.00	Compression
	748SB-5C	10	L	125.0	8.0	3.25	1.19	6.25	Compression
	748SB-6C	6	C	72.0	7.0	3.25	3.00	4.50	Compression Water Soluble Chloride
	748SB-7C	2	C	110.0	10.0	3.25	3.00	4.50	Compression
	748SB-1P	24	L	27.0	10.0	3.25	1.50	4.50	Petrography & Air Voids
	748SB-2P	13	L	53.0	1.0	3.25	1.50	5.50	Petrography & Air Voids
	748SB-3P	12	C	111.0	3.0	3.25	3.00	4.50	Petrography & Air Voids
	748SB-4P	2	R	78.0	8.0	3.25	2.13	5.88	Petrography & Air Voids

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Compression Results

Table 2 summarizes the compression testing results of the concrete cores.

Table 2: Compression Testing Summary							
Core ID	Diameter (in)	As-Prepared Length (in)	Cross Sectional Area (in^2)	Ultimate Load (lbs.)	L/D Ratio	Correction Factor	Compressive Strength (psi)
748NB-1C	3.25	4.58	8.30	59,560	1.41	0.949	6,810
748NB-2C	3.25	4.07	8.30	71,990	1.25	0.930	8,070
748NB-3C	3.25	4.46	8.30	57,020	1.37	0.945	6,490
748NB-4C	3.25	5.48	8.30	56,400	1.69	0.975	6,630
748NB-5C	3.25	5.90	8.30	35,240	1.82	0.987	4,190
748NB-6C	3.25	4.50	8.30	55,520	1.38	0.946	6,330
748NB-7C	3.25	4.10	8.30	67,340	1.26	0.931	7,560
748SB-1C	3.25	4.51	8.30	62,500	1.39	0.947	7,130
748SB-2C	3.25	6.26	8.30	31,590	1.93	0.999	3,800
748SB-3C	3.25	4.45	8.30	42,580	1.37	0.944	4,850
748SB-4C	3.25	3.66	8.30	51,450	1.13	0.900	5,580
748SB-5C	3.25	5.93	8.30	58,020	1.82	0.988	6,910
748SB-6C	3.25	3.62	8.30	50,180	1.11	0.897	5,430
748SB-7C	3.25	4.59	8.30	44,160	1.41	0.950	5,050
Average Compression Strength (psi)							6,060

The failure mode of the tested cores was generally consistent with a Type 1 fracture pattern. A Type 1 fracture pattern is defined in ASTM C39 as having reasonably well-formed cones on both ends with less than 1 inch of cracking through the capped ends.

The average compressive strength of the cores extracted from the northbound sections of structure 748 was 6,580psi. The average compressive strength of the cores extracted from the southbound sections of structure 748 was 5,540 psi. There were two (2) cores 748NB-5C and 748SB-2C that were significantly less than 5000 psi. Due to the lower strength of these test results, Pennoni recommends impact echo testing results be reviewed.

Water Soluble Chloride Ion Testing

Cores 748NB-4C, 748NB-5C, 748SB-2C and 748SB-6C were randomly selected for water soluble chloride ion testing. Testing was performed at three depths from the surface of the structural concrete; 0.5 inch, 1 inch and 2 inch. The thickness of the concrete overlay wearing surface at locations 748NB-4C and 748NB-5C were 2.00 inches and 1.25 inches respectively. The thickness of the concrete overlay wearing surface at locations 748SB-2C and 748SB-6C were 1.00 inch and 3.00 inches respectively. Table 3 summarizes the concentrations of water soluble chloride ions for each tested core.

Table 3 - Water Soluble Chloride Ion Test Results						
Bridge	Core ID	Depth (in)	Cl- (%wt)	Cl- (ppm)	Cl- (lbs/yrd^3)	Cl- (% cement)
I-748	748NB-4C	-0.50	0.00046	5	0.02	0.00
	748NB-4C	-1.00	0.00023	2	0.01	0.00
	748NB-4C	-2.00	0.00014	1	0.01	0.00
	748NB-5C	-0.50	0.00140	14	0.05	0.01
	748NB-5C	-1.00	0.00084	8	0.03	0.01
	748NB-5C	-2.00	0.00059	6	0.02	0.00
	748SB-2C	-0.50	0.01332	133	0.52	0.10
	748SB-2C	-1.00	0.00449	45	0.18	0.03
	748SB-2C	-2.00	0.00215	21	0.08	0.02
	748SB-6C	-0.50	0.00986	99	0.39	0.07
	748SB-6C	-1.00	0.00526	53	0.21	0.04
	748SB-6C	-2.00	0.00174	17	0.07	0.01

The following assumptions were used in order to estimate the water soluble chloride concentrations as a function of pound per cubic yard of concrete and as a percent of cement mass.

1. The air dry density of normal weight concrete is 3915 pounds per cubic yard (145 pounds per cubic foot).
2. The cement content is assumed as 14% for normal weight concrete.

ACI 318 Chapter 4 Table 4.3.1 provides requirements for maximum concentrations of water soluble chlorides for C2 structures as 0.15. C2 structures are defined as structures exposed to external sources of moisture and chlorides from deicing chemicals. The results listed in Table 3 indicate that the concentrations of water soluble chlorides are lower than this limit and are practically nonexistent at the depth of the top layer of reinforcing steel (i.e. 2 inches from the surface). These results indicate that the reinforcing steel within this structure is not in a corrosive environment and should be in as good a condition as originally placed. These data also indicates that the concrete overlay wearing surface is providing adequate protection to the concrete structural slab at most of the locations. The chloride concentration is slightly high at the top of the structural slab at location 748SB-2C. This could be due to the overlay thickness at this location was only 1 inch.

Pull Testing of Overlay Wearing Surface

Pull testing of the concrete overlay wearing surface was performed at core locations 748NB-1C to 748NB-7C and 748SB-1C to 748SB-7C. The overlay thickness at these locations varied from 1.00 inches to 3.13 inches. The pull testing was performed in general compliance with ASTM C1583. A 3 inch diameter cored hole was drilled through the overlay wearing surface and into the underlying concrete slab by approximately 0.5 inches. A 3 inch diameter steel disk was then epoxied to the surface of the overlay and pulled at a constant rate until failure. The application of tensile load was monitored using an inline dynamometer. Table 4 summarizes the results from the overlay pull testing.

Table 4 - Pull Test Results of Concrete Overlay Wearing Surface					
Bridge	Core ID	Load Area (in^2)	Tensile Load (lbs)	Bond Strength (psi)	Failure Type
I-748	748NB-1C	7.07	100	14	Bond Fail
	748NB-2C	7.07	750	106	Bond Fail
	748NB-3C	7.07	100	14	Bond Fail
	748NB-4C	7.07	100	14	Bond Fail
	748NB-5C	7.07	750	106	Bond Fail
	748NB-6C	7.07	750	106	Bond Fail
	748NB-7C	7.07	1000	141	Bond Fail
	748SB-1C	7.07	1000	141	Bond Fail
	748SB-2C	7.07	1500	212	Bond Fail
	748SB-3C	7.07	1000	141	Bond Fail
	748SB-4C	7.07	250	35	Bond Fail
	748SB-5C	7.07	2000	283	Bond Fail
	748SB-6C	7.07	100	14	Bond Fail
	748SB-7C	7.07	1200	170	Bond Fail

The bond strengths listed in Table 4 have a wide range of results ranging from 14 psi to 283 psi. ACI 345 – Concrete Highway Bridge Deck Construction does not list values for the bond strength between the substructure and the concrete wearing surface. However, developing a good bond between the two surfaces is a fundamental requirement for most concrete overlay wearing surfaces. Without an adequate bond, the overlay wearing surface is susceptible to delamination which can range from localized minor spalling or the removal of extensive sections. In both cases, the removal of the wearing surface allows the infiltration of various chemicals and weather conditions to attack the underlying structure. The concrete repair institute (ICRI) generally notes that bond strengths should not be below 100 psi. Locations with very low bond strengths should be investigated further, possibly in companion with the results from the impulse echo testing to confirm possible delamination of the overlay surface.

Petrography and Air Voids

Cores 748NB-1P – 748NB-4P and 748SB-1P – 748SB-4P were sent to Highbridge Materials Consulting, Inc. for petrography and air voids. The following is a summary of the test results, for further information; please reference *"Petrographic Examination Report"*, prepared by Highbridge Materials Consulting, Inc. dated March 22, 2015.

The total air voids observed in cores 748NB-1P, 748NB-2P, 748NB-3P and 748NB-4P was 5.2%, 5.1%, 5.1% and 6.8% respectively. The total air voids observed in cores 748SB-1P, 748SB-2P, 748SB-3P and 748SB-4P was 8.7%, 5.6%, 5.6% and 9.1% respectively. The air contents for cores 748SS-1P and 748SB-4P exceed modern specifications for concrete that is exposed to freezing and thawing. The air contents for the remaining cores are within modern specifications. Current specifications for concrete exposed to freezing and thawing cycles is 3.5% to 6.5% per ACI 318 Chapter 4 Section 4. Concrete with high air content may have lower compressive strengths. There were two instances where the compressive strengths of the cores were significantly lower than the other tested cores; these lower compressive strengths could be the result of higher air void contents.

It was also noted that the air void structures in cores 748NB-2P, 748NB-3P and 748SB-3P had high spacing factors. Concrete with poorly developed air structures tend to have durability issues due to the imbalance of correctly sized voids to accommodate water infiltration and expansion during freezing events.

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PENNONI ASSOCIATES INC.
CONSULTING ENGINEERS

March 27, 2015

Design Level Inspection Report
I-95 Wilmington Viaduct

Re: Concrete Coring and Testing Services
Bridge I-748N Northbound
I-95 Viaduct, Wilmington, DE

Pennoni Associates (Pennoni) visited the above referenced structure on the nights of November 19, 2014, December 17 and 21, 2014 and January 11, 2015 to drill and extract concrete core samples and perform overlay pull testing. A total of nine (9) concrete cores were extracted and transported to our laboratory where they were documented and tested for thickness, compressive strength and water soluble chloride ions. Three (3) cores, 2 from the 2 lane segment and 1 from the 3 lane segment of the structure, were sent to Highbridge Materials, Inc. for petrography and air voids. Table 1 below summarizes the physical dimensions, locations and selected testing for each of the concrete cores extracted from Bridge I-748N.

Table 1 - Core Locations, Dimensions and Prescribed Testing

Bridge	Core ID	Core Location				Core Diameter (in)	Core Thickness		Laboratory Testing
		Span	Lane	Distance from Joint (X) (ft)	Distance from Lane Line (Y) (Ft)		Overlay (in)	Structural (in)	
I-748 (N2)	748N2-1C	29	R	67.0	6.0	3.25	3.00	4.75	Compression
	748N2-2C	37	L	46.0	2.5	3.25	2.25	4.88	Compression Water Soluble Chloride
	748N2-3C	45	L	52	7.5	3.25	2.75	4.25	Compression
	748N2-1P	32	R	19.0	6.0	3.25	2.00	5.50	Petrography & Air Voids
	748N2-2P	45	L	67.0	5.5	3.25	2.50	3.75	Petrography & Air Voids
I-748 (N3)	748N3-1C	52	L	12.0	5.0	3.25	2.25	4.50	Compression Water Soluble Chloride
	748N3-2C	55	R	23.5	5.5	3.25	2.75	3.25	Compression
	748N3-3C	58	C	15.0	7.0	3.25	2.00	6.00	Compression
	748N3-1P	57	R	21.0	11.0	3.25	2.75	5.00	Petrography & Air Voids

Pull testing was performed at six (6) locations. Three (3) tests were performed adjacent to the compression core locations on both the two lane and three lane segments of the structure.

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Compression Results

Table 2 summarizes the compression testing results of the concrete cores.

Table 2: Compression Testing Summary							
Core ID	Diameter (in)	As-Prepared Length (in)	Cross Sectional Area (in^2)	Ultimate Load (lbs.)	L/D Ratio	Correction Factor	Compressive Strength (psi)
748N2-1C	3.25	4.58	8.30	52,990	1.41	0.949	6,060
748N2-2C	3.25	4.58	8.30	41,220	1.41	0.949	4,720
748N2-3C	3.25	3.66	8.30	48,520	1.13	0.900	5,270
748N3-1C	3.25	3.92	8.30	41,380	1.21	0.920	4,590
748N3-2C	3.25	3.47	8.30	54,710	1.07	0.886	5,840
748N3-3C	3.25	5.49	8.30	52,570	1.69	0.975	6,180
Average Compression Strength (psi)							5,440

The failure mode of the tested cores was generally consistent with a Type 1 fracture pattern. A Type 1 fracture pattern is defined in ASTM C39 as having reasonably well-formed cones on both ends with less than 1 inch of cracking through the capped ends.

Water Soluble Chloride Ion Testing

Cores 748-N2-2C and 748-N3-1C were randomly selected for water soluble chloride ion testing. Testing was performed at three depths from the surface of the structural concrete; 0.5 inch, 1 inch and 2 inch. Both core locations 748-N2-2C and 748-N3-1C had a 2.25 inch thick concrete overlay wearing surface. Table 3 below summarizes the concentrations of water soluble chloride ions for each tested core.

Table 3 - Water Soluble Chloride Ion Test Results						
Bridge	Core ID	Depth (in)	Cl- (%wt)	Cl- (ppm)	Cl- (lbs/yrd^3)	Cl- (% cement)
I-748(N2)	748-N2-2C	-0.50	0.00353	35	0.14	0.03
	748-N2-2C	-1.00	0.00156	16	0.06	0.01
	748-N2-2C	-2.00	0.00039	4	0.02	0.00
I-748(N3)	748-N3-1C	-0.50	0.00026	3	0.01	0.00
	748-N3-1C	-1.00	0.00013	1	0.01	0.00
	748-N3-1C	-2.00	0.00009	1	0.00	0.00

The following assumptions were used in order to estimate the water soluble chloride concentrations as a function of pound per cubic yard of concrete and as a percent of cement mass.

1. The air dry density of normal weight concrete is 3915 pounds per cubic yard (145 pounds per cubic foot).
2. The cement content is assumed as 14% for normal weight concrete.

ACI 318 Chapter 4 Table 4.3.1 provides requirements for maximum concentrations of water soluble chlorides for C2 structures as 0.15. C2 structures are defined as structures exposed to external sources of moisture and chlorides from deicing chemicals. The results listed IN Table 3 indicate that the concentrations of water soluble chlorides are lower than this limit and are practically nonexistent at the depth of the top layer of reinforcing steel (i.e. 2 inches from the surface). These results indicate that the reinforcing steel within this structure is not in a corrosive environment and should be in as good a condition as originally placed. This data also indicates that the concrete overlay wearing surface is providing adequate protection to the concrete structural slab.

Pull Testing of Overlay Wearing Surface

Pull testing of the concrete overlay wearing surface was performed at core locations 748-N2-1C to 748-N2-3C and 748-N3-1C to 748-N3-3C. The overlay thickness at these locations varied from 2.00 inches to 3.00 inches. The pull testing was performed in general compliance with ASTM C1583. A 3inch diameter cored hole was drilled through the overlay wearing surface and into the underlying concrete slab by approximately 0.5 inches. A 3 inch diameter steel disk was then epoxied to the surface of the overlay and pulled at a constant rate until failure. The application of tensile load was monitored using an inline dynamometer. Table 4 below summarizes the results from the overlay pull testing.

Table 4 - Pull Test Results of Concrete Overlay Wearing Surface

Bridge	Core ID	Load Area (in^2)	Tensile Load (lbs)	Bond Strength (psi)	Failure Type
I-748(N2)	748-N2-1C	7.07	1000	141	Bond Fail
	748-N2-2C	7.07	750	106	Bond Fail
	748-N2-3C	7.07	1500	212	Bond Fail
I-748(N3)	748-N3-1C	7.07	1000	141	Bond Fail
	748-N3-2C	7.07	1000	141	Bond Fail
	748-N3-3C	7.07	1200	170	Bond Fail

The bond strengths listed in Table 4 have fairly consistent results ranging from 106 psi to 212 psi. ACI 345 – Concrete Highway Bridge Deck Construction does not list an actual value for the bond strength between the substructure and the concrete wearing surface. However, developing a good bond between the two surfaces is a fundamental requirement for most concrete overlay wearing surfaces. Without an adequate bond, the overlay wearing surface is susceptible to delamination which can range from localized minor spalling or the removal of extensive sections. In both cases, the removal of the wearing surface allows the infiltration of various chemicals and weather conditions to attack the underlying structure. The concrete repair institute (ICRI) generally notes bond strengths should not be below 100 psi.

Petrography and Air Voids

Cores 748N2-1P, 748N2-2P and 748N3-1P were sent to Highbridge Materials Consulting, Inc. for petrography and air voids. The following is a summary of the test results, for further information; please reference *"Petrographic Examination Report"*, prepared by Highbridge Materials Consulting, Inc. dated March 22, 2015.

The total air voids observed in cores 748N2-1P, 748N2-2P and 748N3-1P was 8.1%, 7.5% and 5.2% respectively. The air contents for cores 748N2-1P and 748N2-2P exceed modern specifications for concrete that is exposed to freezing and thawing. The air content for core 748N3-1P was within modern specifications. Current specifications for concrete exposed to freezing and thawing cycles is 3.5% to 6.5% per ACI 318 Chapter 4 Section 4. Concrete with high air content may have lower compressive strengths. The compressive

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PENNONI ASSOCIATES INC.
CONSULTING ENGINEERS

March 27, 2015

Design Level Inspection Report
I-95 Wilmington Viaduct

Re: Concrete Coring and Testing Services
Bridge I-748S Southbound
I-95 Viaduct, Wilmington, DE

Pennoni Associates (Pennoni) visited the above referenced bridge on the nights of December 7, 10, 11 and 18, 2014 to drill and extract concrete core samples and perform overlay pull testing. A total of nine (9) concrete cores were extracted and transported to our laboratory where they were documented and tested for thickness, compressive strength and water soluble chloride ions. Three (3) cores were sent to Highbridge Materials, Inc. for petrography and air voids. Table 1 below summarizes the physical dimensions, locations and selected testing for each of the concrete cores extracted from Structure I-748S.

Table 1 - Core Locations, Dimensions and Prescribed Testing

Bridge	Core ID	Core Location				Core Diameter (in)	Core Thickness		Laboratory Testing
		Span	Lane	Distance from Joint (X) (ft)	Distance from Lane Line (Y) (Ft)		Overlay (in)	Structural (in)	
I-748S	748S-1C	27	L	43.0	2.5	3.25	2.25	5.25	Compression Water Soluble Chloride
	748S-2C	35	L	21.0	10.0	3.25	1.50	4.50	Compression
	748S-3C	39	L	60.0	1.0	3.25	2.00	6.00	Compression Water Soluble Chloride
	748S-4C	44	L	64.0	3.0	3.25	2.25	6.25	Compression
	748S-5C	53	L	22.0	8.0	3.25	2.00	6.25	Compression
	748S-6C	54	R	64.0	8.0	3.25	2.00	5.00	Compression
	748S-1P	27	L	10.0	7.0	3.25	2.25	5.75	Petrography & Air Voids
	748S-2P	45	R	31.0	3.0	3.25	2.00	6.00	Petrography & Air Voids
	748S-3P	57	L	44.0	10.0	3.25	1.50	6.75	Petrography & Air Voids

Pull testing was performed at six (6) locations. The locations selected for the pull testing were directly adjacent to the compression core locations for this structure.

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Compression Results

Table 2 summarizes the compression testing results of the concrete cores.

Table 2: Compression Testing Summary							
Core ID	Diameter (in)	As-Prepared Length (in)	Cross Sectional Area (in^2)	Ultimate Load (lbs.)	L/D Ratio	Correction Factor	Compressive Strength (psi)
748S-1C	3.25	4.88	8.30	45,860	1.50	0.960	5,310
748S-2C	3.25	3.92	8.30	55,460	1.21	0.920	6,150
748S-3C	3.25	6.28	8.30	40,070	1.93	0.999	4,830
748S-4C	3.25	6.41	8.30	47,950	1.97	1.000	5,780
748S-5C	3.25	6.10	8.30	39,860	1.88	0.993	4,770
748S-6C	3.25	4.49	8.30	55,100	1.38	0.946	6,280
Average Compression Strength (psi)							5,520

The failure mode of the tested cores was generally consistent with a Type 1 fracture pattern. A Type 1 fracture pattern is defined in ASTM C39 as having reasonably well-formed cones on both ends with less than 1 inch of cracking through the capped ends.

Water Soluble Chloride Ion Testing

Cores 748S-1C and 748S-3C were randomly selected for water soluble chloride ion testing. Testing was performed at three depths from the surface of the structural concrete; 0.5 inch, 1 inch and 2 inch. The core at location 748S-1C had a 2.25 inch thick concrete overlay wearing surface. The core at location 748-3C had a 2.00 inch thick concrete overlay wearing surface. Table 3 summarizes the concentrations of water soluble chloride ions for each tested core.

Table 3 - Water Soluble Chloride Ion Test Results						
Bridge	Core ID	Depth (in)	Cl- (%wt)	Cl- (ppm)	Cl- (lbs/yrd^3)	Cl- (% cement)
I-748S	748S-1C	-0.50	0.00125	13	0.05	0.01
	748S-1C	-1.00	0.00105	10	0.04	0.01
	748S-1C	-2.00	0.00039	4	0.02	0.00
	748S-3C	-0.50	0.00084	8	0.03	0.01
	748S-3C	-1.00	0.00044	4	0.02	0.00
	748S-3C	-2.00	0.00026	3	0.01	0.00

The following assumptions were used in order to estimate the water soluble chloride concentrations as a function of pound per cubic yard of concrete and as a percent of cement mass.

1. The air dry density of normal weight concrete is 3915 pounds per cubic yard (145 pounds per cubic foot).
2. The cement content is assumed as 14% for normal weight concrete.

ACI 318 Chapter 4 Table 4.3.1 provides requirements for maximum concentrations of water soluble chlorides for C2 structures as 0.15. C2 structures are defined as structures exposed to external sources of moisture and chlorides from deicing chemicals. The results listed In Table 3 indicate that the concentrations of water soluble chlorides are lower than this limit and are practically nonexistent at the depth of the top layer of reinforcing steel (i.e. 2 inches from the surface). These results indicate that the reinforcing steel within this structure is not in a corrosive environment and should be in as good a condition as originally placed. This data also indicates that the concrete overlay wearing surface is providing adequate protection to the concrete structural slab.

Pull Testing of Overlay Wearing Surface

Pull testing of the concrete overlay wearing surface was performed at core locations 748S-1C to 748S-6C. The overlay thickness at these locations varied from 1.50 inches to 2.25 inches. The pull testing was performed in general compliance with ASTM C1583. A 3inch diameter cored hole was drilled through the overlay wearing surface and into the underlying concrete slab by approximately 0.5 inches. A 3 inch diameter steel disk was then epoxied to the surface of the overlay and pulled at a constant rate until failure. The application of tensile load was monitored using an inline dynamometer. Table 4 summarizes the results from the overlay pull testing.

Table 4 - Pull Test Results of Concrete Overlay Wearing Surface

Bridge	Core ID	Load Area (in^2)	Tensile Load (lbs)	Bond Strength (psi)	Failure Type
I-748S	748S-1C	7.07	750	106	Bond Fail
	748S-2C	7.07	1200	170	Bond Fail
	748S-3C	7.07	500	71	Bond Fail
	748S-4C	7.07	750	106	Bond Fail
	748S-5C	7.07	750	106	Bond Fail
	748S-6C	7.07	1200	170	Bond Fail

The bond strengths listed in Table 4 had fairly consistent results ranging from 71 psi to 170 psi. ACI 345 – Concrete Highway Bridge Deck Construction does not list values for the bond strength between the substructure and the concrete wearing surface. However, developing a good bond between the two surfaces is a fundamental requirement for most concrete overlay wearing surfaces. Without an adequate bond, the overlay wearing surface is susceptible to delamination which can range from localized minor spalling or the removal of extensive sections. In both cases, the removal of the wearing surface allows the infiltration of various chemicals and weather conditions to attack the underlying structure. The concrete repair institute (ICRI) generally notes bond strengths should not be below 100 psi.

Petrography and Air Voids

Cores 748S-1P, 748S-2P and 748S-3P were sent to Highbridge Materials Consulting, Inc. for petrography and air voids. The following is a summary of the test results, for further information; please reference *"Petrographic Examination Report"*, prepared by Highbridge Materials Consulting, Inc. dated March 22, 2015.